DEPARTMENT OF APPLIED MATHEMATICS,
UNIVERSITY COLLEGE, UNIVERSITY OF LONDON

DRAPERS' COMPANY RESEARCH MEMOIRS

STUDIES IN NATIONAL DETERIORATION. V.

ON THE INHERITANCE OF THE DIATHESES OF PHTHISIS AND INSANITY. A STATISTICAL STUDY BASED UPON THE FAMILY HISTORY OF 1500 CRIMINALS

BY

CHARLES GORING, M.D., B.Sc.

CAMBRIDGE UNIVERSITY PRESS
C. F. CLAY, MANAGER
LONDON: FETTER LANE, E.C. EDINBURGH: 100, PRINCES STREET
H. K. LEWIS, 136, GOWER STREET, LONDON, W.C.
WILLIAM WESLEY AND SON, 28, ESSEX STREET, LONDON, W.C.
CHICAGO: UNIVERSITY OF CHICAGO PRESS
BOMBAY, CALCUTTA AND MADRAS: MACMILLAN AND CO., LIMITED
TORONTO: J. M. DENT AND SONS, LIMITED
TOKYO: THE MARUZEN-KABUSHIKI-KAISHA

1909

Price Three Shillings.

DEPARTMENT OF APPLIED MATHEMATICS,
UNIVERSITY COLLEGE, UNIVERSITY OF LONDON

DRAPERS' COMPANY RESEARCH MEMOIRS

STUDIES IN NATIONAL DETERIORATION. V.

ON THE INHERITANCE OF THE DIATHESES OF PHTHISIS AND INSANITY. A STATISTICAL STUDY BASED UPON THE FAMILY HISTORY OF 1500 CRIMINALS

BY

CHARLES GORING, M.D., B.Sc.

CAMBRIDGE UNIVERSITY PRESS
C. F. CLAY, MANAGER
LONDON: FETTER LANE, E.C. EDINBURGH: 100, PRINCES STREET
H. K. LEWIS, 136, GOWER STREET, LONDON, W.C.
WILLIAM WESLEY AND SON, 28, ESSEX STREET, LONDON, W.C.
CHICAGO: UNIVERSITY OF CHICAGO PRESS
BOMBAY, CALCUTTA AND MADRAS: MACMILLAN AND CO., LIMITED
TORONTO: J. M. DENT AND SONS, LIMITED
TOKYO: THE MARUZEN-KABUSHIKI-KAISHA

1909

On the Inheritance of the Diatheses of Phthisis and Insanity. A statistical Study based upon the Family Histories of 1500 *Criminals.*

By CHARLES GORING, M.D., B.Sc.

(I) *Introductory.* Any cursory inspection of appropriate statistics is sufficient
of constitutional disease. To
ıbordinate one, to estimate its
ı and in relation to a host of
:quire delicate statistical treat-
f heredity, the best, if not the
nal distribution, in the form of
ıy Pearson, when studying the
ıd of pulmonary tuberculosis†;
the inheritance of the insane
the data in any selected series
the occurrence of some special
hich, in some cases, may prove
ɔe is to determine the intensity
latively to the intensity of its
roblem, it is not only essential
curs: it is equally essential to
not occur. And this is where
'or elucidating the problem of
ɔcted family records of Asylum
ɔw often healthy and diseased
ɔen they beget children, who,
diseased. But what Asylums

Journal, May 27, 1905.
sis (Inheritance)," *Drapers' Research*

heritance of the Insane Diathesis,"

Eugenics Laboratory Memoirs III, Dulau and Co.

and Hospitals &c. are obviously unable to supply, is the additional information, essential for the completion of a representative four-fold table, as to families when both parents and all their children, without any exception, are healthy. We have to fall back upon calculation from other statistics for the needed information: that is to say, we have to argue from assumption: the results being not so reliable, nor the evidence so clear, as they would have been if arrived at by direct observation. In their works referred to, both Pearson and Heron had to combat this difficulty of indirect information. To complete the tables compiled from their data so that these tables might be representative of the general population, they both had to rely upon a calculation based to a certain extent upon assumption. This assumption, in the case of Pearson, was that between 9 °/₀ and 12 °/₀, most probably about 10 °/₀, of the general population at some time in their lives suffer from pulmonary tuberculosis. Heron's assumption was that between 1 °/₀ and 2 °/₀ of all people are at some time certified insane. Now although the evidence adduced for both these assumptions was highly reasonable, it could not, from its very nature, be accepted as fully satisfactory. As Pearson said in his memoir :—" the most satisfactory method of studying the influence of heredity on the occurrence of special diseases undoubtedly would be to obtain a large random sample of the family histories of the general population."

It is claimed that the present contribution will, to a certain extent, meet the difficulty above referred to, by its basis of family histories which do represent, in the author's opinion, a random sample of the general population as far as the diseases under consideration are concerned; and this view is maintained in spite of the fact that at least one member in each of these families is, or has been, a convicted felon. If it be objected that consumption and insanity may be more common to criminal than to non-criminal stock, we can only reply that the objection is unsupported by evidence. On the other hand the classes to which the families we have quoted belong are sufficiently varied to be quite representative of the general population, 11 °/₀ of the families belong to the well-to-do classes, 27 °/₀ to the poor, and the remainder to the very poor and the destitute. It is in the justice of the assertion that the data employed are actually representative, that this paper finds its *raison d'être* and defines its two-fold purpose: namely, (1) to consider, with regard to the inheritance of phthisis and insanity, how far the conclusions arrived at by Pearson and Heron, and how far the assumptions upon which their conclusions were partly based, agree with the results obtained entirely by direct observation; (2) to present some new evidence with regard to the part played by infection, as opposed to inheritance, in the occurrence of pulmonary tuberculosis amongst the general population of this country.

(II) *Material.* The material which forms the basis of this paper is part of the data resulting from an extensive survey recently carried out by the medical staff in the service of the Prison Commission, upon the inmates of convict prisons. It consists of a series, collected by the author, of 723 family histories of convicts, concerning which definite information was given in each case as to the occurrence or non-occurrence, in parents and children, of pulmonary tuberculosis; and of a series, similarly

collected, of 1433 histories in which corresponding information was given with regard to insanity. Any histories in which the information given was doubtful, were excluded from the enquiry. In every history was recorded the total number of members in the family, the age of one member with his position in the family, and the number of members who had survived to the ages of 14 and 23 respectively. In histories where phthisis or insanity had occurred, there was also noted the position in the family of those afflicted, and whether the onset of the disease in each was prior to or after the age of 23; but the age of the patient when the disease commenced and his age at death were unfortunately not recorded.

(III) *The Inheritance of Pulmonary Tuberculosis.*

(*a*) *Tabulation of Data.* The information in 723 family histories relating to the incidence of Pulmonary Tuberculosis is briefly given in the following tables:

Total Offspring.

Parents		Children				
Tubercular	No.	Tubercular	Not Tubercular	Total	Average family	Percentage affected
Father only	46	60	297	357	7·76	16·81
Mother only	43	58	219	277	6·44	20·90
Father and Mother ...	3	3	12	15	5·00	20·00
Neither	631	114	4643	4757	7·53	2·39
Total	723	235	5171	5406	7·47	4·34

Offspring surviving to Age 14.

Parents		Children				
Tubercular	No.	Tubercular	Not Tubercular	Total	Average family	Percentage affected
Father only	46	60	182	242	5·26	24·79
Mother only	43	58	179	237	5·51	24·47
Father and Mother ...	3	3	5	8	2·66	37·50
Neither	631	114	3538	3652	5·78	3·12
Total	723	235	3904	4139	5·72	5·67

Offspring surviving to Age 23.

Parents		Children				
Tubercular	No.	Tubercular	Not Tubercular	Total	Average family	Percentage affected
Father only	46	51	149	200	4·34	25·50
Mother only	43	48	128	176	4·10	27·27
Father and Mother ...	3	3	2	5	1·66	60·00
Neither	631	106	2979	3085	4·88	3·43
Total	723	208	3258	3466	4·79	6·00

Age Distribution.
Tubercular Stock.

Mean age of family	Number of families
14—25	24
26—30	19
31—40	21
41—50	14
51—60	14
Total ...	92

Mean Age of Onset.
Rivers and Pearson's Crossley Records.

Sex	Mean Age	S. D.
Males.....	29·1	9·8
Females.....	25·3	8·6

It will be seen from the above tables that although, with increasing age, the ratio between tubercular children of tubercular parents and tubercular children of healthy parents does not sensibly vary, the ratio between the tubercular and healthy offspring of all parents varies very perceptibly as the age of the children increases to 14 and 23. This was to be expected, and it expresses the fact that many people, apparently healthy, are potentially tubercular: they have inherited the tubercular diathesis, and although well to-day will pass to-morrow into the ranks of the recognised tubercular. This change occurs whether or no the parents are tubercular, and allowance must be made for it when dealing statistically with the problem of inheritance. With the present records, the necessity for making this allowance, even when dealing only with the offspring who have survived to the age of 23, is shewn by comparing the table of "age distribution" with Pearson's table of "mean age of onset." The mean age of onset for both sexes taken together is about 27; the standard deviation is about 9 years. It follows from this that between the ages of 14 and 45 may be looked upon roughly as a danger zone for tubercular infection. The modal value of age of onset is about 23, and this is the age when the danger of

infection is most intense: the danger diminishing fairly rapidly to the age of 14, and more gradually to the age of 45. Now, all individuals who have survived to the age of 23 have passed into this zone and have reached its maximum point of danger; but they have not necessarily all left the zone: they are not all out of danger of infection. In our series, over 70 °/₀ are still being menaced to a greater or lesser extent, and some proportion of those who are likely to succumb must be allowed for in the statistical treatment of these records. An interesting point to be noted in this connection is that although, as we have just pointed out, the danger zone is not entered until the age of 14, yet the percentage of children infected amongst those who have survived at the age of 14 is much larger than the percentage amongst the total offspring. The reason for this is apparent when the two tables are compared. The increased percentage is not due to an increase of the tubercular. It is due to a decrease of the not tubercular—many infants and children, recorded as not tubercular, having died from other causes before reaching the danger zone of tubercular infection. Thus is emphasized the importance of allowing for completion of family history when dealing with the problem of inheritance.

The increased percentage of infected children borne by infected mothers, as shewn in the table relating to total offspring, is not maintained in the succeeding tables. The point will be referred to later when dealing with the theory of infection.

The chief point of interest with regard to the average sizes of family of tubercular and of not tubercular parents is that the fertility of the former is consistently rather less than that of the latter. In relation to this slightly decreased fertility, it is worth noting to what extent, upon the evidence in these records, the tubercular in one generation are replaced by the tubercular in the next. We see that 92 infected parents have 102 infected, and 279 not infected children who have survived to the marriageable age of 23. On a basis of 33 °/₀ as the minimum proportion of tubercular children in completed families, this 102 will finally increase to 130 infected of whom, according to the Registrar-General's report, 80 °/₀, i.e. 101 will become parents. According to these figures the incidence of pulmonary phthisis ought to be slowly increasing, supposing (i) that the marriage rate among the tubercular is as high as among the not tubercular; and (ii) that precautionary measures have not lessened the risk of infection to an individual with a given grade of diathesis. Both of these assumptions are, however, hardly probable.

(*b*) *Statistical Treatment of Data.* Counting each child twice over, once for each parent, and treating male and female parents apart from each other, the data in the previous tables can be rearranged as follows:

Total Offspring.

Father

Offspring	Tubercular	Not Tubercular	Total
Tubercular	$63+y$	$172+z$	$235+y+z$
Not Tubercular...	$309-y$	$4862-z$	$5171-y-z$
Total	372	5034	5406

Mother

Offspring	Tubercular	Not Tubercular	Total
Tubercular	$61+y$	$174+z$	$235+y+z$
Not Tubercular...	$231-y$	$4940-z$	$5171-y-z$
Total	292	5114	5406

The only point for consideration here is to decide the numerical values which should be attached to the two unknowns, y and z, which represent, as already explained, the not tubercular children who have not yet passed through the danger zone and are menaced by infection. One thing, at any rate, seems quite clear. It is that whatever the value of y ought to be, the value of z must be in such simple numerical relation to it, that the final ratio between tubercular and not tubercular parents will not be in any way modified. Reference to the "age distribution" table will shew that practically all the parents of the subjects, where ages are recorded in that table, are well on the safe side of the danger zone; and that most of them must, at the date of the record, have already left this zone well behind them. The ratio, then, between tubercular and not tubercular parents must be looked upon as finally fixed, and ought not to be modified by any correction made upon the ratio between tubercular and not tubercular children. The only way to determine the value of y is to consult statistics of completed family histories; and the idea suggests itself of referring to the certain limited number of these contained in our own series. Amongst our 92 families with tubercular parentage, there are 20 with completed history—that is to say, the youngest member in each is 45 years old or older. Consulting these, we learn that 33 °/₀ of the children in completed families are tubercular. This estimate is too low because the records of the particular families we have consulted, although complete, are not representative of all completed family histories. Those families, ravaged by consumption, with histories prematurely completed by death, are obviously not represented at all; whereas the families of mild diathesis, where many have escaped infection, are represented in excess. We may consider, however, this 33 °/₀, obtained directly from our records, as a minimum limit of infection in completed families. As a maximum limit, we will assume the 50 °/₀ quoted by Pearson from Dr Thompson's record of families with completed tubercular history.

Firstly, then, considering $y = 0$; secondly, calculating y on the basis that 33 °/₀ of the offspring of tubercular parents are tubercular; thirdly, deducing its values on the basis of 50 °/₀ tubercular; moreover, in every case, calculating the values of x from the values of y, so that the original ratio between tubercular and not tubercular parents remains unchanged—our original four-fold table may be expressed in the following forms:

TABLE I. *Total Population. Random Samples.*

Incomplete family History.

Children	Father: Tubercular	Father: Not Tubercular	Father: Total	Mother: Tubercular	Mother: Not Tubercular	Mother: Total
Tubercular ...	63	172	235	61	174	235
Not Tubercular	309	4862	5171	231	4940	5171
Total	372	5034	5406	292	5114	5406

TABLE II. *Family History completed on 33 °/₀ basis.*

Children	Father: Tubercular	Father: Not Tubercular	Father: Total	Mother: Tubercular	Mother: Not Tubercular	Mother: Total
Tubercular.....	124	338	462	97	277	374
Not Tubercular	248	4696	4944	195	4837	5032
Total	372	5034	5406	292	5114	5406

TABLE III. *Family History completed on 50 °/₀ basis.*

Children	Father: Tubercular	Father: Not Tubercular	Father: Total	Mother: Tubercular	Mother: Not Tubercular	Mother: Total
Tubercular ...	186	507	693	146	417	563
Not Tubercular	186	4527	4713	146	4697	4843
Total	372	5034	5406	292	5114	5406

These tables, reduced by the usual method, yield the following coefficients for the correlation in parental inheritance of Pulmonary Tuberculosis:

Father and Offspring.

Table I. The equation is:

$$\cdot 709146 = r + 1\cdot 27078r^2 + \cdot 38594r^3 + \cdot 05901r^4,$$

$$r = \cdot 437.$$

Table II. The equation is:

$$\cdot 82392 = r + 1\cdot 0165r^2 + \cdot 1756r^3 + \cdot 0758r^4,$$

$$r = \cdot 519.$$

Table III. The equation is:

$$\cdot 92165 = r + \cdot 8426r^2 + \cdot 0578r^3 + \cdot 0956r^4,$$

$$r = \cdot 597.$$

Mother and Offspring.

Table I. The equation is:

$$\cdot 88407 = r + 1\cdot 3756r^2 + \cdot 5091r^3 + \cdot 0033r^4,$$

$$r = \cdot 491.$$

Table II. The equation is:

$$\cdot 97383 = r + 1\cdot 1909r^2 + \cdot 3156r^3 + \cdot 0332r^4,$$

$$r = \cdot 555.$$

Table III. The equation is:

$$1\cdot 0788 = r + 1\cdot 01116r^2 + \cdot 15389r^3 + \cdot 0499r^4,$$

$$r = \cdot 631.$$

Turning now to the data limited to offspring who have survived to age 14, and arranging it as before, we get:

TABLE IV. *Population aged 14 and upwards. Random Samples.*

Incomplete Family History.

Father

Children	Tubercular	Not Tubercular	Total
Tubercular ...	63	172	235
Not Tubercular	187	3717	3904
Total	250	3889	4139

Mother

	Tubercular	Not Tubercular	Total
Tubercular ...	61	174	235
Not Tubercular	184	3720	3904
Total	245	3894	4139

TABLE V. *Family History completed on* 33 °/₀ *basis.*

Father

Children	Tubercular	Not Tubercular	Total
Tubercular ...	83	227	310
Not Tubercular	167	3662	3829
Total	250	3889	4139

Mother

	Tubercular	Not Tubercular	Total
Tubercular ...	82	234	316
Not Tubercular	163	3660	3823
Total	245	3894	4139

TABLE VI. *Family History completed on* 50 °/₀ *basis.*

Father

Children	Tubercular	Not Tubercular	Total
Tubercular ...	125	341	466
Not Tubercular	125	3548	3673
Total	250	3889	4139

Mother

	Tubercular	Not Tubercular	Total
Tubercular ...	122	348	470
Not tubercular	123	3546	3669
Total	245	3894	4139

From these tables we get the following equations and correlation coefficients:

Father and Offspring.

Table IV. The equation is:

$$\cdot 86337 = r + 1\cdot 22747 r^2 + \cdot 35264 r^3 + \cdot 03009 r^4,$$

$$r = \cdot 504.$$

Table V. The equation is:

$$\cdot 91716 = r + 1\cdot 1172 r^2 + \cdot 2517 r^3 + \cdot 05109 r^4,$$

$$r = \cdot 544.$$

Table VI. The equation is:

$$1\cdot 02217 = r + \cdot 94085 r^2 + \cdot 11044 r^3 + \cdot 07109 r^4,$$

$$r = \cdot 622.$$

Mother and Offspring.

Table IV. The equation is:

$$\cdot 84621 = r + 1\cdot 2355 r^2 + \cdot 3606 r^3 + \cdot 0286 r^4,$$

$$r = \cdot 496.$$

Table V. The equation is:

$$\cdot 90419 = r + 1\cdot 5616 r^2 + \cdot 25058 r^3 + \cdot 04985 r^4,$$

$$r = \cdot 539.$$

Table VI. The equation is:

$$\cdot 99431 = r + \cdot 94305r^2 + \cdot 11003r^3 + \cdot 06797r^4,$$

$$r = \cdot 609.$$

Finally, from the data of offspring who have survived to age 23, we get the following tables:

TABLE VII. *Population aged 23 and upwards. Random Samples.*

Incomplete Family History.

Children	Father			Mother		
	Tubercular	Not Tubercular	Total	Tubercular	Not Tubercular	Total
Tubercular ...	54	154	208	51	157	208
Not Tubercular	151	3107	3258	130	3128	3258
Total	205	3261	3466	181	3285	3466

TABLE VIII. *Family History completed on 33 °/₀ basis.*

Children	Father			Mother		
	Tubercular	Not Tubercular	Total	Tubercular	Not Tubercular	Total
Tubercular ...	68	194	262	60	185	245
Not Tubercular	137	3067	3204	121	3100	3221
Total	205	3261	3466	181	3285	3466

TABLE IX. *Family History completed on 50 °/₀ basis.*

Children	Father			Mother		
	Tubercular	Not Tubercular	Total	Tubercular	Not Tubercular	Total
Tubercular ...	102	291	393	90	277	367
Not Tubercular	103	2970	3073	91	3008	3099
Total	205	3261	3466	181	3285	3466

The equations and correlation coefficient are as follows:

Father and Offspring.

Table VII. The equation is:

$$\cdot 85728 = r + 1\cdot 2142r^2 + \cdot 34005r^3 + \cdot 05669r^4,$$

$$r = \cdot 503.$$

Table VIII. The equation is:

$$\cdot 90312 = r + 1\cdot 1210r^2 + \cdot 2544r^3 + \cdot 0049r^4,$$

$$r = \cdot 536.$$

Table IX. The equation is:

$$1\cdot 00387 = r + \cdot 94397r^2 + \cdot 1106r^3 + \cdot 00674r^4,$$

$$r = \cdot 617.$$

Mother and Offspring.

Table VII. The equation is:

$$\cdot 91048 = r + 1\cdot 2622r^2 + \cdot 3865r^3 + \cdot 0223r^4,$$

$$r = \cdot 518.$$

Table VIII. The equation is:

$$\cdot 94303 = r + 1\cdot 1940r^2 + \cdot 31718r^3 + \cdot 0301r^4,$$

$$r = \cdot 540.$$

Table IX. The equation is:

$$1\cdot 04637 = r + 1\cdot 0138r^2 + \cdot 1525r^3 + \cdot 00442r^4,$$

$$r = \cdot 620.$$

(*c*) *Comparisons and Conclusion.* From comparison of these tables and the results of their analysis, many slight differences appear; but none that are very startling. It will be noticed that the general effect on the tables of limiting the offspring to those over 14 and 23 is much the same as the effect produced by completing the family histories. This is best shewn by comparing Tables I, IV, VII, VIII and IX in order. They form a progressive series in which the ratio between tubercular and not tubercular children and the proportion of total tubercular to total population gradually increases, and with them a corresponding increase in the value of r. In the same way, the difference with regard to these points between Tables I and II is greater than the difference between Tables IV and V, which is again greater

than the difference between Tables VII and VIII, which is very small indeed. In fact, the effect of the age limit has been almost to convert Table I into Table II. It will be noticed throughout the whole series that, however the tables are modified, the ratio between tubercular and not tubercular parents changes very slightly. Thus, although the ratio between tubercular and not tubercular children varies from 1 in 22 in the first table to 1 in 9 in the last table, that between tubercular and not tubercular parents changes only from 1 in 14 to 1 in 16. Theoretically, there should have been no variation at all. The slight difference in this ratio between mothers and fathers is probably not significant. The intensity of inheritance is on the whole slightly greater in females than males.

To resume: The essential purpose of the investigation was to compare our results—results obtained by analysis of a sample of the general population, with those obtained by Pearson working upon Sanatorium data.

Before making this comparison, however, it is important to realize (1) What has been the exact difference in these two investigations? (2) What exactly it is, in the two investigations, that we want to compare? (3) In what conditions the results of the two investigations are comparable? The sole difference exists not in any diversity of method, but in the nature of the material employed. The value of the fourth quadrant in the four-fold table—the quadrant containing the number of not tubercular children of not tubercular parents—was not obtained by Pearson, as it was by us, directly from the records, but was reached by him indirectly on the supposition that one person in every 10 of the general population is either actually or potentially tubercular. Our aim is to compare (1) the relative distribution, arrived at by Pearson on the basis of an hypothesis, and by us from direct observation, of random samples of the general population, classed into tubercular and not tubercular groups; (2) the values of r, i.e. the intensity of the correlation in heredity, represented by these distributions. With regard to the third enquiry, we would say that the only results of these two investigations which are comparable, and which ought to be compared, are those contained in and derived from the tables constructed after completion of the family history. As reference to our series of tables shews, the value of r varies directly, and the ratio between tubercular and not tubercular offspring varies indirectly, with the stage of completion of the family histories. Pearson's first table, for instance, makes no correction for completion of family history. It is a table constructed tentatively, in order to arrive at a proximate idea of the minimum possible limit of the intensity of inheritance. The value of this intensity he found to be ·40. We, following a similar plan, arrived at almost the same value, ·43. These values, however, are not strictly comparable, for this estimation found by Pearson from incomplete families had, by the exigencies of the investigation, to be based upon the supposition, which, of course, refers only to completed families, that 10 °/₀ of the general population are tubercular. The tables, then, that ought to be compared are the final ones: the table which, in both series, yield a maximum value for r, and which represent random samples of the general population after completion of family history to the same extent. Bearing this in mind, the following table fairly compares the results:

		K. Pearson's Memoir	Goring. The present paper
Proportion of general population affected by Pulmonary Tuberculosis	Present generation	10°/₀	11°/₀
„ „ „	Parental generation	4°/₀	5°/₀
Maximum intensity of inheritance		·60	·62
Minimum „ „		·40	·43
Probable „ „		·50	·50

Two conclusions follow from the evidence of this investigation. The first is, to quote Pearson's statement written some years ago, that "the intensity of the inheritance factor in pulmonary tuberculosis is greater than ·4 and less than ·6: that the tubercular diathesis is inherited at the same rate as other physical characters in man are inherited." The other conclusion is that, assuming the above to be the case, the number of the general population affected by pulmonary tuberculosis, in the present generation, is probably nearer to 8 °/₀ than to 10 °/₀*.

(IV) *The Inheritance of the Insane Diathesis.*

(*a*) *Tabulation of Data.* The data given here is contained in 1433 family histories and applies to the incidence of the insane diathesis. Of these histories, 159 relate to convict lunatics confined in Parkhurst State Asylum. They will be considered apart from the remaining 1274 histories which relate to subjects who are convicts, but who, not being themselves insane, may be regarded, in relation to the occurrence of insanity, as a representative sample of the general population. The data is given in the following tables:

General Population.

Parents		Children		
Insane	No.	Insane	Not Insane	Total
Father only	27	12	147	159
Mother only	29	7	149	156
Father and Mother	3	0	19	19
Neither	1215	62	8605	8667
Total	1274	81	8920	9001

* The estimate that 11 °/₀ of the general population are tubercular, as given in the above comparative table, corresponds to ·62 upon the intensity scale of inheritance, and follows from the assumption of Dr Thompson's estimate that 50 °/₀—rather than 33 °/₀ given directly by our own records—of the children of tubercular parents are tubercular. For this reason we suggest in the text that 8 °/₀, resulting from our

Convict Lunatics.

Parents		Children		
Insane	No.	Insane	Not Insane	Total
Father only	8	11	59	70
Mother only	15	22	71	93
Father and Mother	1	1	3	4
Neither	135	150	700	850
Total	159	184	833	1017

(*b*) *Statistical Treatment of Data.* Each child is counted twice over, once for each parent, as before. The male and female pedigrees, however, are fused into one because the data are not sufficient to justify their separate treatment. The assumption is thus made that the two parents are equipotent in hereditary influence. We get, accordingly, the following four-fold tables:

TABLE I. *General Population.*

		Parents	
Children	Insane	Not Insane	Total
Insane	$19+y$	$143+z$	$162+y+z$
Not Insane	$334-y$	$17506-z$	$17840-y-z$
Total ...	353	17649	18002

TABLE II. *Convict Lunatics.*

		Parents	
Children	Insane	Not Insane	Total
Insane	$35+y$	$333+z$	$368+y+z$
Not Insane	$136-y$	$x-z$	$136-y+x-z$
Total ...	171	$333+x$	$504+x$

own estimate of this proportion and corresponding to a correlation coefficient of ·5, is probably nearer to the correct value.

The latest returns give the mortality from pulmonary tuberculosis in England as 7·6 % of all deaths.

To determine y, we have referred to Dr Urquhart's data employed by Heron. This gives 25 °/₀ as the proportion of offspring of insane parents who finally become insane—undoubtedly a minimum percentage. But, to keep our tables in line with those of Heron so that the final results of each may be comparable, we have taken a value for y in accordance with this assumption. The third unknown x in the second table, we have derived from the value reached for the fourth quadrant in the first table, after its correction for completed family history. In determining z from y, the ratio between insane and not insane parents has been left undisturbed as before. Thus corrected, the table becomes:

TABLE III. *General Population.*

Children	Parents: Insane	Parents: Not Insane	Total
Insane	88	662	750
Not Insane	265	16987	17252
Total ...	353	17649	18002

From which the equation is:

$$\cdot 96080 = r + 1\cdot 7856r^2 + 1\cdot 0838r^3 - \cdot 00002r^4,$$

and

$$r = \cdot 47.$$

TABLE IV. *Convict Lunatics.*

Children	Parents: Insane	Parents: Not Insane	Total
Insane	42	399	441
Not insane	129	10014	10143
Total ...	171	10413	10584

From which the equation is:

$$\cdot 9166 = r + 1\cdot 8533r^2 + 1\cdot 1931r^3 - \cdot 00003r^4,$$

and

$$r = \cdot 45.$$

These results compare as follows with those obtained by Heron:

		Heron's Memoir	Goring. The present paper
Proportion of general population with Insane diathesis	Present Generation	2·5°/₀	4·1°/₀
„ „	Parents of last Generation	1·25°/₀	1·9°/₀
Intensity of inheritance		·53	·47

The results agree closely; and in view of a reservation made by Heron with regard to his results, they are even closer than they appear to be. Heron says, "the value (·53) we have obtained is undoubtedly rather high. It is possible that the prevalence of the insane diathesis in the community at large has been underestimated proceeding as we do from the asylum evidence of its existence." Upon the evidence of this investigation we are inclined to agree with Heron's view, and would say that the prevalence of the insane diathesis lies between 3 °/₀ and 4 °/₀, and that the probable intensity of its inheritance is ·50. From which, we can only again conclude that the insane, like the tubercular diathesis, is inherited in the same way, and to the same degree, as other physical characters in man are inherited.

(V) *"Infection" in Pulmonary Tuberculosis.* Before attempting to estimate the relative importance of infection and inheritance in the causation of pulmonary tuberculosis, it is necessary to realize the nature of the parts these factors play in the occurrence of this disease. Since Koch's discovery in 1882, phthisis has been universally recognised as an infective, constitutional disease. It is an infection, because it depends upon an invasion of the body by the tubercle bacillus; the liability to invasion, depending upon a certain inherited quality of bodily tissue, defines the constitutional character of this disease. No difference of opinion, with regard to the causation of phthisis, implies a corresponding division on the truth of the foregoing doctrine. The most staunch upholder of the all importance of the "heredity" factor in phthisis would not discredit the existence of Koch's bacillus, nor the part it plays in the occurrence of the disease. The most rabid of the infectionist school would not dispute that the vulnerability of the tissues to the attacks of the bacillus is a heritable quality. The difference of opinion with regard to the causation of phthisis resides in the relative importance to be attached to these two factors and in the definition of their nature and limitations. An extreme infectionist believes that a tissue, vulnerable by inheritance, may be made resistant by appropriate treatment and conduct of life; he believes that, in hygienic conditions of life, the bacillus is warred against and killed or that, at any rate, it may be avoided. He also believes that a tissue, naturally resistant by inheritance, may become vulnerable in a debilitating environment, or by repeated association with the bacillus. In support of this view, he offers clinical and pathological testimony of individual cases. The extreme view in the other camp is the opposite to this. Here, heredity

counts for everything. With an inherited diathesis, man is powerless: the bacillus is all powerful. And the ubiquitous bacillus, save in very exceptional circumstances, cannot be avoided. Its ultimate extinction will depend upon an inherited improvement in the human stock, and not upon hygiene. In support of this view, statistical evidence is presented of consumptives taken in the mass. The problem at issue resolves itself into this. Is the liability to infection influenced by environment? Is the influence of inheritance, as manifested by the relative incidence of phthisis in tainted and untainted stocks, modified by circumstances? In dealing with these questions, one thing at any rate may be confidently stated. It is this: that the nature of the problem is such, that its ultimate solution must rest upon a statistical basis. In the absence of statistics, it is idle to quote clinical evidence of individual cases. The fate of individuals is entirely beside the point in question: which is, whether, on the whole, and in the long run, taking consumptives in the mass, statistics shew that the influence of certain circumstances has modified either the liability of infection, or the inherited tendency of the body to be infected.

Three conditions, in particular, have imposed themselves on the general belief as singularly conducive to infection. These are, (1) that adults become more liable to infection by intimate association with the bacillus; (2) that children, so prone to infection by zymotic diseases, are peculiarly liable to infection from tubercular parents or relations with whom they are in constant intercourse; (3) that the airless, sunless, and general unhygienic condition of the homes and lives of the poor render them more liable, than the well-to-do classes, to infection. The following evidence is concerned with the above three contentions.

In dealing with the first contention we would enquire: Does an individual become more liable to phthisis by marriage with a tubercular mate? If the liability to phthisis is increased by intimate association with the source of its infection, we would expect the incidence of phthisis to be increased by this marital condition. That is to say, in a series of couples married at random, we would expect the intensity of correlation between husband and wife, both suffering from phthisis, to be positive and significant. With regard to this point our data previously given may be arranged as follows:

Marital Correlation Table.

Husband \ Wife	Tubercular	Not Tubercular	Total
Tubercular	3	46	49
Not Tubercular...	43	631	674
Total	46	677	723

This leads to the equation:

$$-\cdot0072 = r + 1\cdot1384r^2 + \&c.,$$

which gives

$$r = -\cdot0072.$$

The correlation of infection by tubercular disease from association in marriage is both negative and insignificant. That is to say, healthy individuals are not, upon the evidence of our data, infected by marriage with tubercular mates.*

The second contention leads to an examination of our data, with the enquiry whether children of tubercular mothers are more prone to infection than the children of tubercular fathers. Children are more closely and constantly associated with their mothers than they are with their fathers; consequently, if they are infected by contagion from phthisis in at all the same way as they are infected, say, from measles, we ought to find the children of tubercular mothers yielding the greater percentage of consumptives. Referring to the previous tables of data we find:

Difference between Maternal and Paternal Inheritance.

	Percentage of infected children		Intensity of Inheritance		Difference with mothers	
	Of Tubercular Fathers	Of Tubercular Mothers	Male Pedigrees	Female Pedigrees	Per cent.	*r*
Total Offspring.....	16·8	20·9	·44	·49	+ 4·1	+ ·05
Offspring survived to age 14	24·8	24·5	·50	·50	− 0·3	·00
Offspring survived to age 23	25·5	27·3	·50	·52	+ 1·8	+ ·02

On the whole, there is a slight excess with mothers over fathers, and this excess expresses the intensity of the infection—if so small a difference can be considered significant. The larger excess, when total offspring are considered, means, partly, that the tubercular mothers in this series were less fertile than the tubercular fathers. The latter have, consequently, more offspring who have not yet reached the danger zone of infection, and who are, in the meantime, all being classed as not tubercular.

For statistical evidence relating to the last contention, that the poor are more liable to phthisis than the well-to-do classes, we have divided our original data into two groups. The first group consists of individuals drawn from classes of the very poor and destitute; the second group comprises individuals from the prosperous poor and well-to-do classes. The following tables give the data thus redistributed.

* Some data published on August 21st in the *British Medical Journal*, by Dr Theodore Williams, are interesting in their relation to adult infection. The data consist of information regarding the infection by phthisis of the staff employed at the Brompton Hospital for Consumptives, since the year 1882. Briefly stated, out of 369 individuals whose histories have been followed through many years, 12, i.e. 3·2°/₀ have developed phthisis during some time in their life. Assuming that individuals of tainted stock would not be likely to take service in a consumption hospital, we would compare Dr Williams' data with our 3090 individuals of *not tubercular* parentage, given below, Table II, page 21. Of these 3090, 79, i.e. 2·6°/₀ were tubercular. Thus, out of a sample population divided into two groups—the first exposed to great special risk of infection, the second exposed to ordinary risks—the prevalence of phthisis in the former group is only ·6°/₀ greater than amongst the latter. In consideration of the facts that the average intensity of diathesis is the same for the two groups, and that two of the hospital cases were associated with inoculation wounds, this small difference does not seem very significant. If we omit these two cases the percentages for both sets of material are practically identical, namely 2·6°/₀ and 2·7°/₀.

TABLE I. *Very Poor and Destitute.*

Parents Tubercular		Children	
	No.	Tubercular	Not Tubercular
Father only	23	31	123
Mother only	16	21	81
Father and mother	0	0	0
Neither	222	35	1632
Total	261	87	1836

TABLE II. *Well-to-do.*

Parents Tubercular		Children	
	No.	Tubercular	Not Tubercular
Father only	23	29	174
Mother only	27	37	138
Father and mother	3	3	12
Neither	409	79	3011
Total	462	148	3335

This data again rearranged gives:

TABLE I. *Very Poor and Destitute.*

Parental Correlation.

Family History completed on basis of 33 °/₀.

Children	Parents: Tubercular	Parents: Not Tubercular	Total
Tubercular	85	199	284
Not Tubercular	171	3391	3562
Total	256	3590	3846

TABLE II. *Well-to-do.*

Parental Correlation.

Family History completed on basis of 33 °/₀.

Children \ Parents	Tubercular	Not Tubercular	Total
Tubercular	136	423	559
Not Tubercular	272	6135	6407
Total	408	6558	6966

Table I gives the equation:

$$\cdot 9515 = r + 1\cdot 0872r^2 + \cdot 2294r^3 + \cdot 0609r^4,$$

$$r = \cdot 563.$$

Table II gives the equation:

$$\cdot 8509 = r + 1\cdot 0995r^2 + \cdot 23522r^3 + \cdot 0512r^4,$$

$$r = \cdot 526.$$

Comparative Table.

Class	Intensity of Inheritance	Percentage Tubercular in Population	
		Children	Parents
Very poor and destitute	·56	7·4°/₀	6·6°/₀
Well-to-do	·53	8·0°/₀	5·8°/₀
Difference	·03 ± ·04	·6°/₀	·8°/₀

The only conclusion we can draw from such figures is that, amongst the less favoured classes, there is a slightly greater incidence of phthisis. But the intensity of the inheritance of this disease is clearly *not* modified by class distinctions and social conditions.

The same result may be reached more directly by arranging the data of the class distribution of phthisis in one table, thus:

Class Correlation in Phthisis.

Incomplete Family Histories.

Class*	Tubercular	Not Tubercular	Total
Destitute	87	1836	1923
Well-to-do.....	148	3335	3483
Total	235	5171	5406

From which the equation:

$$\cdot 0183 = r + \cdot 3166 r^2 + \&c.,$$

and

$$r = \cdot 018.$$

If we take into consideration its probable error—$\pm \cdot 04$—this correlation between poverty, with all the environmental conditions it involves, and the occurrence of phthisis is insignificant. However, when we come to examine closely the general trend of the figures in Tables I and II, and to compare these with the results of their reduction summarised in the above comparative table, we are struck by two facts. The first is that tubercular disease, at any rate amongst individuals who are parents, does seem to be slightly less prevalent amongst the prosperous classes, and is associated rather more with poverty than it is with riches. The second is that despite of this difference in the class prevalence of phthisis, there is no change in the parental correlations sufficient to deduce any corresponding modification in the potency of inheritance. Admitting that the prevalence of phthisis is reduced amongst the rich and others protected from special risks of infection, yet with poor and rich alike the disease still tends to run in certain stocks with unchanging intensity: the same proportion of phthisical cases are still associated with phthisical parentage. And in view of the fact that the intensity of this parental association has been found on the whole a trifle greater for phthisis than for insanity and other physical characters in man, it is a fair inference that perhaps some small part of the parental correlation in this disease may be due to infection. But, upon statistical evidence, one conclusion alone seems to follow inevitably and may be asserted without reserve. It is that such parental infection, if existent, is relatively inconsiderable and that almost the whole of the parental association in phthisis represents an inherited predisposition in the child to be infected with the disease of his parents: that the one vital factor in the occurrence of tuberculosis is inheritance.

To summarise the principal conclusions, which follow directly from the figures contained in all the foregoing tables, the following propositions seem appropriate:

* It is assumed that the two classes dealt with in this table are represented in their right numerical proportions. Any correction that might have to be made for precise accuracy in this respect would not be likely to lead to any very significant difference in the correlation coefficient.

(1) In the main, the present paper, starting from different material, and proceeding by a quite different method to Pearson's in his memoir, indicates that the tubercular diathesis is inherited; and is inherited at the same rate as all other physical characters in man.

(2) The prevalency of tuberculosis in the population—taking the duration of individual life as the unit—lies between 8 °/₀ and 10 °/₀, and is probably nearer the lower limit.

(3) In the class dealt with, there is no evidence of marital infection: which, in our opinion, goes to prove that the incidence of phthisis in both husband and wife, noted by Pope, Greenwood and others, may be due to the assortative mating, based on psychical affinities, of the educated classes among which they chiefly made their observations. The higher correlation reached by Pearson, working upon records of consultants' private practice amongst the cultivated classes, corroborates this view.

(4) There is no definite evidence that the correlation between parents and offspring is greater in the poorer classes, where environment would increase the liability to infection. This is consistent with the correlation being largely hereditary in character.

(5) The importance of the hereditary factor as opposed to direct contagion in the causation of phthisis is supported by the facts (1) that the prevalence of phthisis amongst children of infected mothers is not appreciably greater than it is amongst the children of infected fathers; (2) that the prevalence of phthisis amongst workers exposed to constant infection in a consumptive hospital has been found to be not significantly greater than amongst individuals with the same degree of diathesis in the general population.

(6) The criminal data confirm Heron in his conclusion as to the inheritance of the insane diathesis, and presents a correlation between parents and offspring sensibly the same as the correlation in phthisis. The supporters of the theory that tuberculosis is influenced more by contagion than by inheritance, who believe that the correlation between parents and offspring results either because contagion, or because the same surroundings render members of the same family more liable to infection, are driven to a conclusion that could hardly be maintained seriously: the conclusion that although the correlation between parents and offspring which, in insanity, must be due to inheritance, is the same as in phthisis, yet in phthisis this correlation is not due to inheritance but indicates infection.

(7) The prevalence of insanity—the life of the individual being taken as unit—appears somewhat greater than the value assumed by Heron, or else it is greater in criminal stock as distinguished from the normal population. With regard to the latter it must be remembered that criminals, who were also lunatics, were excluded from this investigation.

Briefly and imperfectly we have, in this paper, touched upon a subject so interesting that it has seemed to justify the publication of all data, and of all evidence, which might help in any way to elucidate a problem of the highest practical importance.

APPENDIX.

COMPARISON OF ASSORTATIVE MATING WITH REGARD TO TUBERCULOSIS AND OTHER QUALITIES.

Some data, recently published*, relating to marital infection, illustrate the kind of evidence which, although frequently cited, can only confuse the issue and can never throw any real light on statistical problems of this order. The data in question consist of a series of cases, each of a most remarkable and exceptional kind, selected by the occurrence of a dual tubercular infection in successive marriages of the same individual. The series, unanalysed, looks a formidable one and, in a superficial judgment, might appear to provide convincing evidence that the liability to tubercular infection is considerably increased by marriage with an individual already suffering from this disease. We cannot, however, form any real opinion of the value of these exceptional data until we know their precise numerical relationship to the common experience: until we know how many thousands of cases there were, associated with these exceptional data, representing the common order of things. The question is, are we, in this series, dealing with examples of healthy individuals, who have been infected with phthisis solely because of their marriage with tubercular mates; or, are we dealing with individuals, who, having inherited the tubercular diathesis, have become tubercular in the ordinary course and despite of their intermarriage? Are we dealing with examples of cause and effect, or of chance concomitance? Now, there is no *a priori* reason why two potentially tubercular individuals should not intermarry, nor why, of any such two, the one who survives the other should not marry again, and yet again, a second and third potentially tubercular individual. How often such intermarriages might be expected to occur is entirely a matter of probabilities. Assuming the prevalence of the tubercular diathesis in the general community to be one in ten, we should expect out of a hundred married pairs to find one case of both husband and wife phthisical, and, out of a thousand cases of double marriages, to find one case of husband and both his wives phthisical, and so on. It follows then, that before we are in a position to form an opinion whether the marital relationship influences the occurrence of tuberculosis, the first essential is to weigh statistically the *observed* frequency of this condition against its *expected* frequency, and thus determine the marital correlation by the inclination of the beam. As it stands then, these data we have been considering, are of very little, if of any value, as evidence for or against a theory of marital infection in consumption. In fact the citation of any specially selected cases in relation to this problem, is idle and cannot lead to any fruitful result. The utmost information such cases yield is that possibly marital infection does occur sometimes. But since there is an infinite variety

* "A Lecture on the Infection of Consumption," *British Medical Journal*, Aug. 21, 1909.

of ways in which infection may occur the above information does not help towards the solution of the real question of marital infection, which is whether on the whole the liability to tubercular infection is increased by marriage with the tubercular and if so, what is the measure of its intensity relatively to that of other forces and conditions which also determine the occurrence of this disease.

Briefly stated, the steps to be taken when seeking a solution to this problem are these: (1) To obtain data from a sufficiently large series of marriages taken at random; (2) To determine from the data thus obtained the marital correlation coefficient, that is the degree of tubercular resemblance between husband and wife, and to record the result on a scale between +·1 and −·1; (3) To determine by comparison and analogy with other coefficients of a similar kind, how far the result obtained is dependent on infection, and how far upon other causes, independent of tuberculosis, but inseparable from the marital condition. With regard to this last, from the marital correlation coefficients obtained by Ethel M. Elderton, Pearson, and other investigators, the fact has been fairly established that there is a very significant resemblance between husband and wife with regard to a variety of physical and mental characters, and that the average intensity of this resemblance, known as the intensity of "assortative mating," lies between ·15 and ·25. Also G. G. Pope*, Greenwood†, and others, working upon large series of data, have obtained very similar coefficients for tuberculosis in husband and wife. And in view of the general recognition of the existence of a tubercular type‡, the recognition that particular habits of mind and body are associated with the tubercular diathesis, it is considered highly probable that most of this marital resemblance in tuberculosis is due to assortative mating, and that at most only a small residue is significant of marital infection. That is the view of the matter held at present, and it is confirmed by the insignificant marital correlation coefficient obtained in this paper by working upon data of a social class where, as we may probably assume, mating is far more casual and any sexual selection is influenced more by grosser physical, than by the finer physical, or any mental affinities.

In support of this last contention that "assortative mating" is influenced by social class, we have now obtained some further evidence which it seemed worth while to record. We have divided our original data into various class groups as before, and have determined the marital correlation coefficients for different conditions. The data and results are given in the following table.

It must be briefly explained with regard to this table that the correlation coefficients were calculated by the four-fold method; that for the three cases where, the data as to H − W − being 0, the determination of the coefficients could yield only

* "A second study of the statistics of Pulmonary Tuberculosis: Marital Infection," *Drapers' Research Memoirs.* Dulau & Co.

† "The problem of marital infection in Pulmonary Tuberculosis," *Proceedings of Royal Society of Medicine*, June, 1909.

‡ The existence of this tubercular "type" has been often referred to in medical literature, but has not yet been considered statistically.

Marital correlation.

Character	Class of Population	Number of Couples	Husband+ Wife−	H− W+	H+ W+	H− W−	% H+	% W+	Correlation coefficient r
Pulm^{y} Tuberculosis	All	723	46	43	3	631	6·8	6·4	−·01
,,	Well-to-do and prosperous poor	462	23	27	3	409	5·6	6·5	+·16
,,	Very poor and destitute	261	23	16	0	222	8·8	6·1	− ?
Insanity	All	1433	35	44	4	1350	2·7	3·3	+·06
,,	Well-to-do and pros. poor	493	6	13	1	473	1·4	2·8	+·35
,,	Very poor and destitute	257	14	10	0	233	5·4	3·9	− ?
Criminality	All	474	25	2	3	444	5·9	1·1	+·20
,,	Well-to-do and pros. poor	321	9	1	0	311	2·8	·3	?
,,	Very poor and destitute	153	16	1	3	133	12·4	2·6	+·18
Alcoholism	All	1426	277	26	109	1014	27·1	9·5	+·70
,,	Well-to-do	65	7	1	2	55	13·8	4·6	+·69
,,	Prosperous poor	244	61	7	21	155	33·6	11·5	+·58
,,	Very poor and destitute	151	53	6	17	75	46·3	15·2	+·44
Freedom from constitutional disease*	All	437	75	63	275	24	80·1	77·3	+·11
,,	Well-to-do and pros. poor	296	53	45	181	17	79·1	76·3	+·08
,,	Very poor and destitute	141	22	18	94	7	82·3	80·0	+·17
Either Insanity or Phthisis† ...	All	485	44	47	5	389	10·1	10·7	−·01

a spurious result, the precise values have been omitted; and that any apparent discrepancies in the number of couples examined for different characters has resulted, in each case, from a lack of data—information as to social class having been given in only a limited number of the records at our disposal.

One fact stands out prominently in this table: it is the variable intensity of marital resemblance with the different social classes considered. In most of the characters examined, the value of r consistently increases as we pass upwards in the social scale; a fact which corroborates the view suggested in the body of this paper, that the value higher than ours, obtained by other investigators for the presence of tuberculosis in husband and wife, represents "assortative mating," at any rate for the most part, and infection to a very small if to any degree. And this view is again confirmed by the other facts brought out in this table: (1) That for insanity, where conjugal infection is excluded, the value of r is twice as great as it is for tuberculosis; (2) That for phthisis or insanity—husband and wife suffering, the

* Freedom from any specific pathological taint without regard to the strength or delicacy of constitution.

† The condition looked for was the presence of phthisis in one mate and insanity in the other.

one from phthisis and the other from insanity*—a contingency which excludes the possibility of assortative mating as well as of infection, the marital correlation coefficient is ·01, no value at all; (3) That for chronic alcoholism, where the assortative resemblance might be expected to be reinforced by other influences, the value of r reaches as high as ·7. On the whole the marital correlation coefficients shew a substantial agreement with those obtained by other investigators, a fact of particular confirmatory importance since, unlike those reached by others, the correlations recorded here have been obtained from data of a random sample of the general population. For tuberculosis amongst the well-to-do classes the value (·16) is less than the average value obtained by others (·2); and when the probabilities of "assortative mating" are allowed for no residue is left to account for possibilities of infection. For insanity the value is rather excessive but within the limits defined by Pearson "that the assortative mating in man with regard to insanity lies between ·25 and ·35. For criminality, a character not previously investigated, the value reached (·18) is in conformity with the average value (·2) due to assortative processes for other characters. Finally, with regard to alcoholism, it must be borne in mind that our data relate to the parents of criminals, and that there is a recognised association between alcoholism and crime. The high value (·7) for this parental resemblance is exceptional. It represents assortative mating augmented by other environmental and personal influences and illustrates the kind of value that might be expected for tubercular resemblance in husband and wife, were marital infection an influence in phthisis at all equipotent with that of inheritance.

* Cases of both suffering from the same disease were excluded.

CAMBRIDGE: PRINTED BY JOHN CLAY, M.A. AT THE UNIVERSITY PRESS.

DEPARTMENT OF APPLIED MATHEMATICS.

UNIVERSITY COLLEGE, UNIVERSITY OF LONDON.

A. *Technical Series.*

I. On a Theory of the Stresses in Crane and Coupling Hooks with Experimental Comparison with Existing Theory. By E. S. Andrews, B.Sc. Eng., assisted by Karl Pearson, F.R.S. *Issued.* Price 3*s.*

II. On some Disregarded Points in the Stability of Masonry Dams. By L. W. Atcherley, assisted by Karl Pearson, F.R.S. *Issued.* Price 3*s.* 6*d.*

III. On the Graphics of Metal Arches, with special reference to the Relative Strength of Two-pivoted, Three-pivoted and Built-in Metal Arches. By L. W. Atcherley and Karl Pearson, F.R.S. *Issued.* Price 6*s.*

IV. On Torsional Vibrations in Axles and Shafting. By Karl Pearson, F.R.S. *Issued.* Price 6*s.*

V. An Experimental Study of the Stresses in Masonry Dams. By Karl Pearson, F.R.S., and A. F. Campbell Pollard, assisted by C. W. Wheen, B.Sc. Eng., and L. F. Richardson, B.A. *Issued.* Price 7*s.*

VI. On a Practical Theory of Elliptic and Pseudo-elliptic Arches, with special reference to the ideal Masonry Arch. By Karl Pearson, F.R.S., W. D. Reynolds, B.Sc. Eng., and W. F. Stanton, B.Sc. Eng. *Issued.* Price 4*s.*

VII. On the Graphics of certain Masonry Structures. By N. G. Dunbar, Chadwick Scholar, and Karl Pearson, F.R.S. *Shortly.*

B. *Biometric Series.*

I. Mathematical Contributions to the Theory of Evolution.—XIII. On the Theory of Contingency and its Relation to Association and Normal Correlation. By Karl Pearson, F.R.S. *Issued.* Price 4*s.*

II. Mathematical Contributions to the Theory of Evolution.—XIV. On the Theory of Skew Correlation and Non-linear Regression. By Karl Pearson, F.R.S. *Issued.* Price 5*s.*

III. Mathematical Contributions to the Theory of Evolution.—XV. On the Mathematical Theory of Random Migration. By Karl Pearson, F.R.S., with the assistance of John Blakeman, M.Sc. *Issued.* Price 5*s.*

IV. Mathematical Contributions to the Theory of Evolution.—XVI. On Further Methods of Determining Correlation. By Karl Pearson, F.R.S. *Issued.* Price 4*s.*

V. A Monograph on Albinism in Man. By Karl Pearson, F.R.S., E. Nettleship and C. H. Usher. With numerous photographic, lithographic and colour plates. *Shortly.*

VI. Mathematical Contributions to the Theory of Evolution.—XVII. On Homotyposis in the Animal Kingdom. By E. Warren, D.Sc., A. Lee, D.Sc., Edna Lea-Smith, Marion Radford, and Karl Pearson, F.R.S. *Shortly.*

C. *Studies in National Deterioration.*

I. On the Relation of Fertility in Man to Social Status, and on the changes in this Relation that have taken place in the last 50 years. By David Heron, M.A. *Issued.* Price 3*s.*

II. A First Study of the Statistics of Pulmonary Tuberculosis. Inheritance. By Karl Pearson, F.R.S. *Issued.* Price 3*s.*

III. A Second Study of the Statistics of Pulmonary Tuberculosis. Marital Infection. By the late Ernest G. Pope. Edited by Karl Pearson, F.R.S. with an Appendix by Ethel M. Elderton. *Issued.* Price 3*s.*

IV. The Health of the School-Child in relation to its Mental Characters. By Karl Pearson, F.R.S. *Shortly.*

V. On the Inheritance of the Diatheses of Phthisis and Insanity. A Statistical Study based upon the Family History of 1500 Criminals. By Charles Goring, M.D., B.Sc. *Issued.* Price 3*s.*

Published by the Cambridge University Press, Fetter Lane, E.C.